

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2015/2016

ETM2016 – ANALOG COMMUNICATIONS
(TE)

31 MAY 2016
2:30 p.m. – 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 10 pages with 4 Questions only.
2. Attempt **ALL** questions. Each question carries an equal total mark and the mark distribution for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Analog modulation is an essential element in analog communications.

(i) Give one advantage and one disadvantage of analog angle modulation.

[4 Marks]

(ii) Define the efficiency for analog amplitude modulation. Explain all terms.

[4 Marks]

(b) Proof whether the following signal is an energy or power signal.

$$x(t) = \begin{cases} A \cos 2\pi f_0 t, & -T_0/2 \leq t \leq T_0/2 \\ 0, & \text{elsewhere,} \end{cases}$$

where $f_0 = 1/T_0$.

[5 Marks]

(c) The output signal, $s_2(t)$, of a communication system is depicted as in Fig. Q1(c) below.

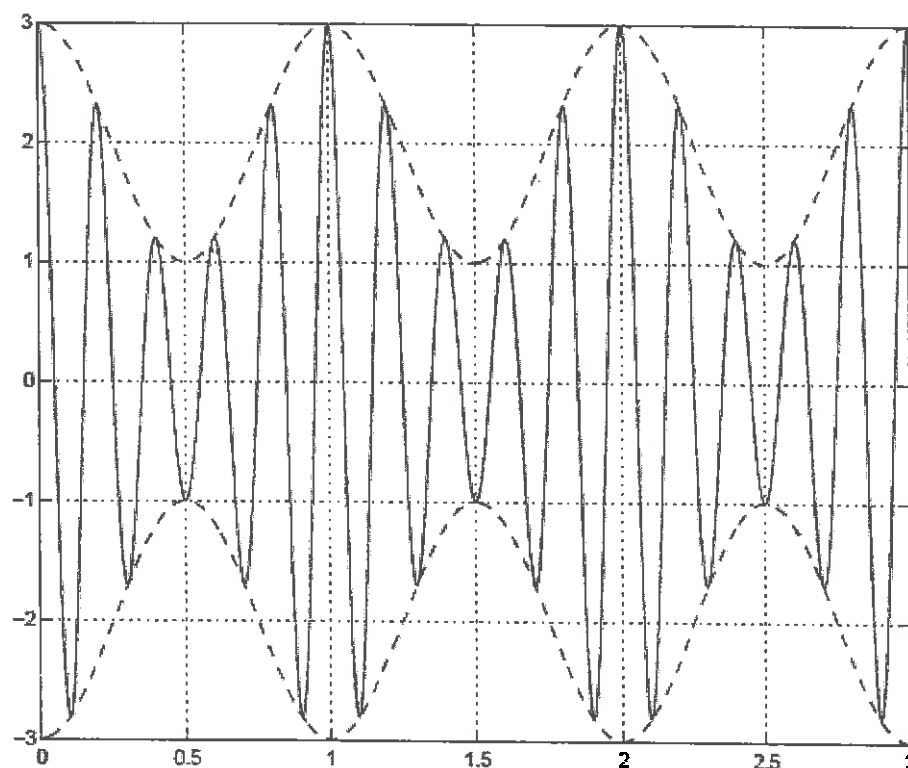


Fig. Q1(c)

(i) What is the corresponding time domain expression ie. $s_2(t)$?

[4 Marks]

(ii) Express the Fourier transform and draw the spectrum of $S_2(f)$. Label the axes.

[8 Marks]

Continued...

Question 2

- (a) A voltage signal $E \sin \omega t$, where t is time, is transmitted through a half-wave rectifier that clips the negative portion of the wave shown in Fig. Q2(a). Determine the Fourier series of the resulting periodic function. The formula is

$$u(t) = \begin{cases} 0 & \text{if } -T < t < 0, \\ E \sin \omega t & \text{if } 0 < t < T \end{cases} \quad T = \frac{\pi}{\omega}$$

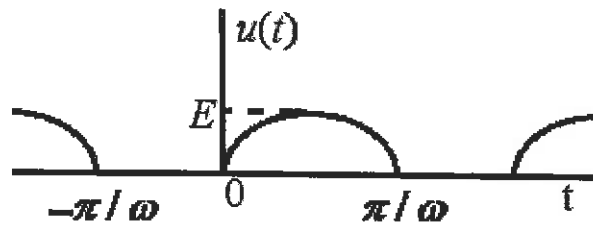


Fig. Q2(a)

[10 Marks]

- (b) Fig. Q2(b) depicts the plot of an analog modulated signal $s_m(t)$, where the analog source signal is given by $x(t) = A_x \cos(2\pi f_x t)$ and the carrier signal is given by $s_c(t) = \cos(2\pi f_c t)$.

- (i) Find the value of the frequency f_c of the carrier signal $s_c(t)$.

[2 Marks]

- (ii) Find the value of the frequency f_x of the analog source signal $x(t)$.

[2 Marks]

- (iii) Determine the modulation index m and decide, whether an envelope detector can be used to recover the source signal $x(t)$ from the modulated signal $s_m(t)$.

[4 Marks]

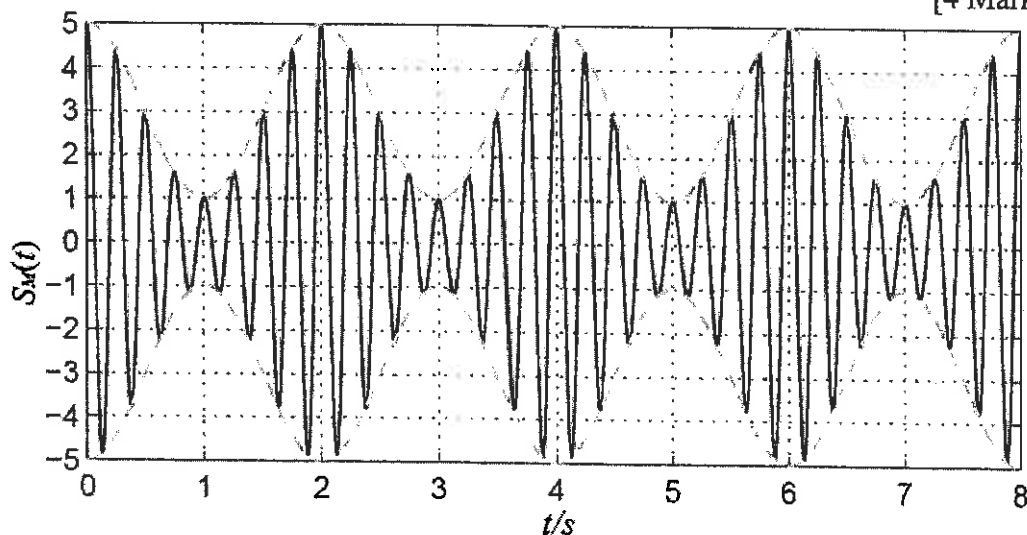


Fig. Q2(b)

Continued...

- (c) **Fig. Q2(c)** displays the amplitude spectrum of a double side band large carrier (DSB-LC) modulated system $Y(\omega)$.

(i) Show and proof whether it is envelope detectable.

[4 Marks]

(ii) Find its power efficiency

[3 Marks]

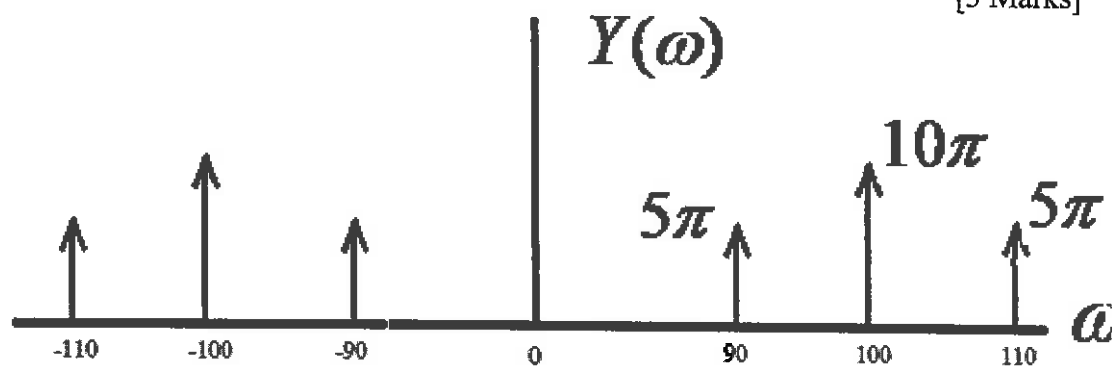


Fig. Q2(c)

Continued...

Question 3

- (a) A signal has the form

$$u(t) = 100 \cos[2\pi f_c t + 4 \sin 2\pi f_m t]$$

where $f_c = 10$ MHz and $f_m = 1000$ MHz

- (i) If this is an FM signal, determine the modulation index and the transmitted signal bandwidth.

[3 Marks]

- (ii) If this is a PM signal, determine the modulation index and the transmitted signal bandwidth.

[3 Marks]

- (b) Balanced modulator is applied to generate double-sideband suppressed-carrier modulation (DSB-SC) signal. With a suitable block diagram, discuss how to generate a DSB-SC signal. Please aid your answer with complete mathematical derivation.

[13 Marks]

- (c) A signal is given as below

$$\varphi_{EM}(t) = 10 \cos(2\pi \cdot 10^6 t + 2 \sin 2\pi 2000 t)$$

It is fed into a frequency multiplier with a factor $N = 5$ to produce the FM signal $y(t)$.

- (i) Find the frequency deviation.

[3 Marks]

- (ii) Determine the bandwidth estimate as per Carson's rule of the signal $y(t)$.

[3 Marks]

Continued...

Question 4

- (a) A time domain signal $m(t)$ is used to frequency modulate a 100 kHz carrier to produce the following narrowband FM signal:

$$\varphi_{NBFM}(t) = 5 \cos(2\pi \cdot 10^5 t + 0.0050 \sin 2\pi \cdot 10^4 t)$$

Determine, via block diagrams, the wideband FM signal $\varphi_{WBFM}(t)$ with a carrier frequency of 75 MHz and a peak frequency deviation of 75 kHz. Assume that the following are available for the design:

- Frequency Multipliers of any integer value.
- A local oscillator whose frequency can be tuned to any value between 50 MHz to 150 MHz.
- An ideal bandpass filter with tunable center frequency and bandwidth.

The block diagram design must clearly specify the carrier frequencies and frequency deviations at all logical points, as well as the center frequency and bandwidth of the bandpass filter.

[11 Marks]

- (b) The noise temperature of an antenna is 50 K. It is connected to a pre-amplifier that has a noise figure of 2 dB and an available gain of 40 dB over an effective bandwidth of 20 MHz.

- (i) Determine the equivalent noise temperature for the pre-amplifier.

[3 Marks]

- (ii) Determine the available noise power of the system.

[3 Marks]

- (c) A superheterodyne receiver is designed with two-cascaded amplifiers. The first amplifier provides a power gain of 100 and contributes $10\mu\text{V}_{\text{rms}}$ noise and the second amplifier provides a power gain of 1000 along with a noise contribution of $50\mu\text{V}_{\text{rms}}$. Assuming that the input signal and noise levels are at $30\mu\text{V}_{\text{rms}}$ and $3\mu\text{V}_{\text{rms}}$ respectively for a 50Ω input impedance, what is the original input signal-to-noise ratio (SNR)? What are the output signal level and noise level after the first amplifier? What are the output signal level and noise level after the second amplifier? What is the final SNR after the two-cascaded amplifiers?

[8 Marks]

Continued...

Appendix I**Trigonometric Preliminaries**

1. $\sin(n\pi) = 0, n = \text{integer}$
2. $\cos(n\pi) = (-1)^n = \begin{cases} 1, & n = \text{even} \\ -1, & n = \text{odd} \end{cases}$
3. $\sin^2 x = \frac{1}{2}(1 - \cos 2x)$
4. $\cos^2 x = \frac{1}{2}(1 + \cos 2x)$
5. $\sin x \sin y = \frac{1}{2}[-\cos(x + y) + \cos(x - y)]$
6. $\cos x \cos y = \frac{1}{2}[\cos(x + y) + \cos(x - y)]$
7. $\sin x \cos y = \frac{1}{2}[\sin(x + y) + \sin(x - y)]$

$$\sin \theta = \frac{1}{2j} [e^{j\theta} - e^{-j\theta}]$$

$$\cos \theta = \frac{1}{2} [e^{j\theta} + e^{-j\theta}]$$

Continued...

Appendix II

Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi f t_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$u(t)$	$\frac{1}{2}\delta(f) + \frac{1}{j2\pi f}$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a > 0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a > 0$
$e^{-a t }$	$\frac{2a}{a^2 + (2\pi f)^2}$, for $a > 0$
$t^n e^{-at}u(t)$	$\frac{n!}{(a+j2\pi f)^{n+1}}$, for $a > 0$
$\text{rect}\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}\text{rect}\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$

Continued...

Appendix III

Fourier Transform Pairs and Properties

$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o) + \frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o) - \delta(f+f_o)]$
$\text{sgn}(t) = \begin{cases} 1 & t > 0 \\ -1 & t < 0 \end{cases}$	$\frac{1}{j\pi f}$
$\frac{1}{\pi t}$	$-j \text{sgn}(f)$
$\sum_{l=-\infty}^{\infty} \delta(t - iT_o)$	$\frac{1}{T_o} \sum_{n=-\infty}^{\infty} \delta(f - \frac{n}{T_o})$
$e^{-at} \cos(2\pi f_o t) u(t)$	$\frac{a + j2\pi f}{(a + j2\pi f)^2 + (2\pi f_o)^2}, \text{ for } a > 0$
$e^{-at} \sin(2\pi f_o t) u(t)$	$\frac{2\pi f_o}{(a + j2\pi f)^2 + (2\pi f_o)^2}, \text{ for } a > 0$
Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Conjugation	$x^*(t) \Leftrightarrow X^*(-f)$
Duality	$X(t) \Leftrightarrow x(-f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{ a } X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f) e^{-j2\pi f t_o}$
Frequency Shifting	$x(t) e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Modulation	$x(t) \cos(2\pi f_o t) \Leftrightarrow \frac{1}{2} X(f - f_o) + \frac{1}{2} X(f + f_o)$
Time Differentiation	$\frac{d^n}{dt^n} x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n} X(f)$

Continued...

Appendix IV

Bessel Function Table

n	$\beta = 0$	$\beta = 0.05$	$\beta = 0.1$	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1$	$\beta = 2$	$\beta = 3$	$\beta = 5$	$\beta = 7$	$\beta = 8$	$\beta = 10$
0	1.000	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178	0.300	0.172	-0.246
1		0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2			0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3					0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4							0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5									0.007	0.043	0.261	0.348	0.186	-0.234
6									0.001	0.011	0.131	0.339	0.338	-0.014
7										0.003	0.053	0.234	0.321	0.217
8											0.018	0.128	0.223	0.318
9											0.006	0.059	0.126	0.292
10											0.001	0.024	0.061	0.207
11												0.008	0.026	0.123
12												0.003	0.010	0.063
13												0.001	0.003	0.029
14													0.001	0.012
15														0.005
16														0.002
17														0.001

	N		N		N		N
$\beta = 0.05$	1	$\beta = 0.7$	4	$\beta = 5$	10	$\beta = 20$	28
$\beta = 0.1$	2	$\beta = 0.8$	4	$\beta = 6$	12	$\beta = 25$	34
$\beta = 0.2$	2	$\beta = 0.9$	4	$\beta = 7$	13	$\beta = 30$	39
$\beta = 0.3$	3	$\beta = 1$	4	$\beta = 8$	14	$\beta = 35$	45
$\beta = 0.4$	3	$\beta = 2$	6	$\beta = 9$	15	$\beta = 40$	50
$\beta = 0.5$	3	$\beta = 3$	7	$\beta = 10$	17	$\beta = 45$	55
$\beta = 0.6$	3	$\beta = 4$	9	$\beta = 15$	22	$\beta = 50$	61

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